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On 5-24-04

TOWNSEND and TOWNSEND and CREW LLP

By: Lisa Karen

PATENT
Attorney Docket No.: 020752-000121US

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: G. Ramanath, et al. Application No.: 09/977,069 Filed: October 11, 2001 For: SELF-ASSEMBLED NEAR-ZERO-THICKNESS MOLECULAR LAYERS AS DIFFUSION BARRIERS FOR CU METALLIZATION	Examiner: Erik Kielin Art Unit: 2813 DECLARATION OF G. RAMANATH PURSUANT TO 37 C.F.R. § 1.132

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

I, G. Ramanath, reside in Clifton Park, NY 12065, and declare as follows:

1. As indicated in the attached biography, I have extensive experience in the fields of microelectronics and materials science.

2. I am a co-inventor in the present patent application.

3. I have reviewed the present application, the Office Action mailed on November 24, 2004, and U.S. Patent Nos. 5,079,600 (Schnur '600) and 5,389,496 (Calvert '496). I have also reviewed the past and present claims that have been presented in this patent application.

4. Independent claim 6 recites "wherein the diffusion barrier is capable of preventing the diffusion of copper atoms from the metal layer into the substrate when the semiconductor device is exposed to thermal annealing at 200 °C or an electric field of 2 MV/cm at 200 °C in flowing N_2". Independent claim 13 recites "wherein the device does not exhibit $j_{leakage} > 1000\ nAcm^{-2}$ when the semiconductor device is exposed to thermal annealing at 200 °C or an electric field of 2 MV/cm in flowing N_2 at 200 °C for up to 650 minutes." Variants of capacitance-voltage (C-V), current-voltage (I-V), C-t, or I-t testing carried out under conditions similar to those mentioned above[1-4], or measurement of metal incorporation by spectroscopic depth profiling, e.g., of samples annealed to higher temperatures (e.g., 500-700 °C) without an electrical bias[5, 6], are commonly accepted benchmarks for evaluating the diffusion barrier properties of interfacial layers between copper, and dielectric or seminconductor materials [7, 8]. Works related to this area in the literature explicitly qualify the efficacy of diffusion barrier properties based on such tests. In this context, I believe that these barrier layer properties are not taught or suggested by Schnur et al., either expressly or inherently. While the Office Action suggests at pages 5-6 of the Office Action that properties such as these are "inherent", Applicants' data in FIG. 3 of the present application show that different molecules exhibit different barrier layer properties. Accordingly, contrary to the Office Action's allegation, I believe that it cannot be presumed that the properties recited in the claims are "inherent".

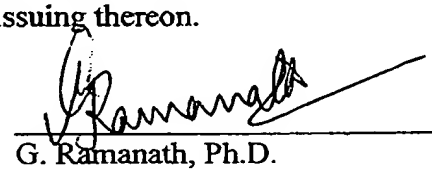
5. At page 4 of the Office Action, the Office Action cites Example 24 and the statement that diffusion of copper was not a problem. However, the molecule used to form a monomolecular film in Example 24 is the same molecule that is used in Example 1, namely, octenyldimethylchlorosilane. This molecule does not have an aromatic group. Applicants have shown, with experimental data, that SAMs with molecules with aromatic groups have better barrier layer properties than SAMs without molecules with aromatic groups.

6. The Office Action also relies on Example 28 which mentions trichloro(4-pyridyl)-ethyl-silane. However, this molecule was deposited on a glass slide, and not on a semiconductor substrate. No device was formed so the limitations "wherein the diffusion barrier is capable of preventing the diffusion of copper atoms from the metal layer into the substrate when the semiconductor device is exposed to thermal annealing at 200 °C or an electric field of 2 MV/cm at 200 °C in flowing N_2" as in independent claim 6 and "wherein the device does not exhibit $j_{leakage} > 1000\ nAcm^{-2}$ when the semiconductor device is exposed to thermal annealing at 200 °C or an electric field of 2 MV/cm in flowing N_2 at 200 °C for up to 650 minutes" as in independent claim 13 cannot be inherent in Schnur et al.

7. At pages 10-11 of the Office Action, the Office Action rejects claims reciting "vapor deposition" or the like by alleging that they are process limitations and that such limitations are not entitled to patentable weight. I have reviewed the article by Yin et al. (Mater. Phys. Mech. 4 (2001) 56-61) and Yin et al. shows that there are non-obvious structural differences in a layer deposited by an electroless plating process and by a vapor deposition process. As shown by FIG. 3 of Yin et al., SEM micrograph c) shows a film formed by vapor deposition, whereas SEM a) shows a film formed by an electroless plating process. As shown, the deposited films have a distinct structural difference, and as noted by page 58, second column of Yin et al., "the vapor phase deposition seemed to show a rougher surface as compared to other processes." Yin shows that electroless plated layers have a different microstructure than vapor deposited layers. Although Yin et al. discusses an Fe-Ni alloy, it is common knowledge (e.g., to materials scientists and crystal growers) that film microstructure is often a strong function of not only the deposition method, but also the deposition conditions. For example, in the case of copper films, it is known that [9, 10] the microstructure of sputter-deposited films have dramatically different microstructures compared to electroplated films. The same general principle applies to films deposited by other means, e.g., chemical vapor deposition[11-13], ion plating[14], electroless plating, or by solid-state methods[15, 16]. The microstructure in turn has a major influence on not only the properties (e.g., smaller grain size usually implies lower electrical conductivity) of the film, but also those related to the adjacent

layers and interfaces (e.g., electromigration resistance, adhesion) [14, 17, 18]. I believe that a vapor deposited layer as in the present claims would generally have a different microstructure, and hence properties, than the electroless metal layer in Schnur, since two different deposition mechanisms are used. Thus, contrary to the Office Action's statement, I believe that the Yin et al. article supports the argument that vapor deposited films generally have different microstructures than electroless layers.

8. I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the above-referenced application or any patent issuing thereon.



G. Ramanath, Ph.D.

5-23-2004

Date

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Texture of Materials. ICOTOM 13. 13th International Conference on Textures of Materials, 26-30 Aug. 2002, vol. 408-412, pp. 1597-602, 2002.

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Development of Microstructure and Texture in Materials for Electronic Applications, 2-4 Nov. 1992, vol. 22, pp. 611-16, 1993.

[11] R. Kroger, M. Eizenberg, D. Cong, N. Yoshida, L. Y. Chen, S. Ramaswami, and D. Carl, "Properties of copper films prepared by chemical vapor deposition for advanced metallization of microelectronic devices," *Journal of the Electrochemical Society*, vol. 146, pp. 3248-54.

[12] R. Kroger, M. Eizenberg, D. Cong, N. Yoshida, L. Y. Chen, and L. Chen, "Nucleation and growth of CVD Cu films," presented at Advanced Interconnects and Contacts. Symposium, 5-7 April 1999, San Francisco, CA, USA, 1999.

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[18] G. Ramanath, H. Kim, H. S. Goindi, M. J. Frederick, C.-S. Shin, R. Goswami, I. Petrov, and J. E. Greene, "Electromigration in epitaxial Cu(001) lines," *AIP Conference Proceedings*
Stress-Induced Phenomena in Metallization. Sixth International Workshop on Stress-Induced Phenomena in Metallization, 25-27 July 2001, pp. 10-20, 2002.

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[Curriculum Vita | Publication list]

Hybrid nanostructures and thin film electronic materials: Synthesis, assembly, modification, and atomic-level engineering and characterization of properties

Professor Ramanath received his Ph.D. in Materials Science and Engineering from the University of Illinois-Urbana in 1997. His doctoral work won him a Materials Research Society Graduate Student Award. He obtained his B.Tech. in Metallurgical Engineering from the IIT, Madras, India, and his M.S. in Materials Science and Engineering from the University of Cincinnati. He was a staff member at Novellus Systems, CA, and a Visiting Scientist at the Physics Department of Linköping University, Sweden, before he joined the Rensselaer faculty in Fall 1998. He is a recipient of a CAREER Award from the National Science Foundation (2000), Prof. Bergmann Memorial Young Scientist Award from the US-Israel Binational Science Foundation (2003), and a co-recipient of IBM Research Partnership Award (1999-2003).

Professor Ramanath's current research interests are in the areas of synthesis, fabrication, assembly, processing, and characterization of hybrid nanostructures and thin films, with emphasis on exploring new materials and architectures for future micro- and nano-devices, and understanding the relationships between atomic-level structure and chemistry, and properties. Current topics being pursued are:

- *Directed assembly of hybrid nanounits and mesoscale heteroarchitectures* comprised of nanotubes, nanoparticles and molecules, through self-assembly, deposition, templating, and surface/interface chemical/physical modification. Probe and understand novel properties. Example projects include forming nanowires from nanoparticles, growing oriented nanotubes networks by combining bottom-up and top-down processing, and synthesizing nanoparticle-nanotube and biomolecule-nanotube heterostructures by site-selective chemical modification and anchoring.
- *Self-assembled nanomolecular layers for thin film interface isolation and adhesion enhancement*: Understand diffusion, interfacial adhesion, coverage, electrical characteristics and thermal stability of ~1-5 nm-thick nanomolecular layers for future devices. Devise new dielectric materials that do not need a diffusion barrier at metal-dielectric interfaces for future device structures.
- *Thin film and interface science*: Understand atomistic pathways and kinetics of interfacial reactions, phase formation and microstructure-stability-property relationships during film growth (e.g., sputter-deposition) and post-deposition treatments (e.g., annealing). Examples include understanding microstructure, phase and interface evolution in Cu alloy films and TiCN

hard coatings and revealing electromigration mechanisms in epitaxial films.

- *Processing and microanalytical techniques* used include CVD, PVD, wet-chemical self-assembly, ion-beam modification, nanofabrication, electron microscopy (conventional and high resolution TEM) electron and X-ray diffraction, various spectroscopies (e.g., RBS, XPS, AES, SIMS, EDX, IR, Raman), AFM, *in situ* electrical measurements and mass-spectrometry during deposition and annealing, 4-point bend interfacial adhesion testing, electrical device testing.

Top

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Publications

EDUCATION

Ph.D.(1997) University of Illinois, Urbana, IL., Materials Science and Engineering
M.S.(1993) University of Cincinnati, OH., Materials Science and Engineering
B.Tech.(1990) Indian Institute of Technology, Madras (now Chennai), India, Department of Metallurgical Engineering

APPOINTMENTS

5/03 – present Tenured Associate Professor, MS&E Department, RPI, Troy, NY
7/98 – 5/03 Tenure-track Assistant Professor, MS&E Department, RPI, Troy, NY
3/98 – 7/98 Visiting Scientist, Physics Department, Linköping University, Sweden
1/97 – 3/98 Member of Technical Staff, Novellus Systems Inc, San Jose, CA

HONORS AND AWARDS

- Prof. Bergmann Memorial Young Scientist Award, US-Israel Binational Science Foundation (2003)
- School of Engineering Research Excellence Award, Rensselaer Polytechnic Institute (2003)
- National Science Foundation CAREER Award (2000)
- IBM Research Partnership Award–University Partnership Program—co-recipient (1999-2003)
- Recent works on nanotubes growth and properties were featured in Science News, Business Review, Washington Times, C&E News, Eetimes, local TV channels (April/May 2002)
- MRS Graduate Student Award, MRS Fall Meeting, Boston, MA (December 1996)
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ADVISEE AWARDS

- Nominee, best poster (Gopal Ganesan), MRS Spring meeting, San Francisco (April 2003)
- Best poster (M.J. Frederick), ASM/TMS Hudson Mohawk chapter (November 2003)
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- 2nd Prize, poster, (Amanda Ellis), ASM/TMS Hudson Mohawk chapter (Nov 2002)
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- 2nd Prize in poster competition (H. Kim), ASM/TMS Hudson Mohawk chapter (Nov 2001)
- Best micrograph award (Rory Leahy) Hudson Mohawk chapter ASM/TMS (Nov '99, '01)

PUBLICATIONS AND TALKS

- 50+ journal articles
- 20 conference articles (7 invited)
- 8 patents (1 issued, 7 filed)
- 50+ invited talks in conferences, colloquia at universities and laboratories
- 32+ contributed conference presentations.

SYNERGISTIC ACTIVITIES

- Associate editor, IEEE Transactions on Nanotechnology (Oct 2003-)
- Director, NSF-REU summer program at the MS&E Department (2001-2003)
- Member, US-Japan Young Scientist Exchange Visit Team in Nanotechnology (2003)
- Symposium Chair, "Mesoscale architectures from nanounits: assembly, fabrication and properties" (GG) Materials Research Society, Fall meeting (Dec 2004)
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- Referee for Applied Physics Letters, Journal of Applied Physics, Chemical Physics Letters, Advanced Materials, Nano Letters, Journal of American Chemical Society, Thin Solid Films, Langmuir, Journal of Nanoscience and Nanotechnology, Materials Letters, Journal of

Physical Chemistry, Materials Science and Engineering, Journal of Vacuum Science and Technology, Surface Coatings and Technology, Applied Surface Science, Vacuum, Journal of Colloids and Interfaces, IEEE Transactions on Nanotechnology, Physics Letters A

- Judge, Materials Research Society Graduate Student Awards (2002)
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- Member, Materials Research Society, American Vacuum Society, The Minerals Metals and Materials Society, American Society of Engineering Education

- Chairman, MS&E Department Graduate Curriculum Committee (August 2002-present)
- Chairman, MS&E Department Colloquium and Distinguished Lecture series(2000-2003)
- Member, Department strategic planning committee (2001-present)
- Member, Committee for faculty search in nanomaterials (Jul 2001-present)
- Created video-modules on RBS and XPS for distance-learning graduate course (1999-2003)
- Faculty advisor, NSF-REU program at the MS&E Department at RPI (1999-2002)
- Chairman of Undergraduate Recruitment Committee (1999-2003)
- Director of Undergraduate Fellowship Program (2000-2002)
- Advisor, for MS&E undergraduates (Spring 1999, 2000)
- Member, Undergraduate curriculum committee (1999-2000)
- Chairman, Undergraduate recruiting committee (1998-2002)
- Advisor, undeclared-major undergraduates (Fall 1999-2002)
- Member, Department Diversity committee (2000)

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3. Trupti. Maddanimath (Primary Advisor: Dr. K. Vijayamohanan, NCL, Pune)
4. Darshan Gandhi
5. Saurabh Agrawal
6. Amit Pratap Singh

Alumni

1. Matt Frederick (PhD, 2003)
2. Mike Stukowski (MS, 2003)
3. Guangchun Cui (MS, 2002)
4. Xiaoyun Guo (MS, 2002)
5. Xiochuan Wang (MS, 2002)
6. Harmeet Goindi (MS, 2001)
7. Kaushik Chanda (MS, 2001)

POST-DOCTORAL ASSOCIATES

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2. Dr. M. Frederick
3. Dr. A. Kumar
4. Dr. Victor Pushparaj (co-advised)

Alumni

1. Dr. Matt Frederick
2. Dr. J. D'Arcy-Gall
3. Dr. A. Ellis
4. Dr. A. Cao (co-advised)
5. Dr. K. Vijayamohanan (sabbatical 09/01-2/02)
6. Dr. R. Goswami
7. Dr. B. Wei (co-advised)
8. Dr. A. Krishnamoorthy
9. Dr. Z. Zhang (co-advised)

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1. A. Wise(RPI, '04 - present)
2. W. Joost (RPI, Spring, '03 - present)
3. S. Anderson (Wash. State U., '03)
4. L. Snedeker (Mich. Tech. '03)
5. J. Reindieu (RPI, '03)
6. J. Michalicek (RPI, '02)
7. L. Underwood (RPI, '03)
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9. Casey Rhodes (RIT, '02)
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11. O. Ahmadi (Yale, '01)
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15. Chitra Baid (RPI, '00-'02)
16. Erin McLellan (RPI, '01)
17. Ji-Hun Kim (RPI, '01)
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19. Ray Pang (RPI, '00)
20. Mike Ziegerhofer (RPI, '00)
21. Dirk Scholvin (RPI, '99, '00)
22. Rory Leahy (Trinity college, Ireland, '99)
23. Mark Wilkinson (RPI, '99)
24. Matt Stowe (RPI, '99)
25. Greg Verni (RPI, '99)
26. Jon Belfort (U. Roch, '98)

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Main Page

Publications

EDUCATION

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- Chairman of Undergraduate Recruitment Committee (1999-2003)
- Director of Undergraduate Fellowship Program (2000-2002)
- Advisor, for MS&E undergraduates (Spring 1999, 2000)
- Member, Undergraduate curriculum committee (1999-2000)
- Chairman, Undergraduate recruiting committee (1998-2002)
- Advisor, undeclared-major undergraduates (Fall 1999-2002)
- Member, Department Diversity committee (2000)

GRADUATE STUDENTS

Current PhD candidates

1. Howard. Kim

2. Raghuveer Makala
3. Trupti. Maddanimath (Primary Advisor: Dr. K. Vijayamohanan, NCL, Pune)
4. Darshan Gandhi
5. Saurabh Agrawal
6. Amit Pratap Singh

Alumni

1. Matt Frederick (PhD, 2003)
2. Mike Stukowski (MS, 2003)
3. Guangchun Cui (MS, 2002)
4. Xiaoyun Guo (MS, 2002)
5. Xiochuan Wang (MS, 2002)
6. Harmeet Goindi (MS, 2001)
7. Kaushik Chanda (MS, 2001)

POST-DOCTORAL ASSOCIATES

Current

1. Dr. P.G. Ganesan
2. Dr. M. Frederick
3. Dr. A. Kumar
4. Dr. Victor Pushparaj (co-advised)

Alumni

1. Dr. Matt Frederick
2. Dr. J. D'Arcy-Gall
3. Dr. A. Ellis
4. Dr. A. Cao (co-advised)
5. Dr. K. Vijayamohanan (sabbatical 09/01-2/02)
6. Dr. R. Goswami
7. Dr. B. Wei (co-advised)
8. Dr. A. Krishnamoorthy
9. Dr. Z. Zhang (co-advised)

UNDERGRADUATE RESEARCHERS

1. A. Wise(RPI, '04 - present)
2. W. Joost (RPI, Spring, '03 - present)
3. S. Anderson (Wash. State U., '03)
4. L. Snedeker (Mich. Tech. '03)
5. J. Reindieu (RPI, '03)
6. J. Michalicek (RPI, '02)
7. L. Underwood (RPI, '03)
8. K. Dusling (Cooper Union, '02)
9. Casey Rhodes (RIT, '02)
10. A. Giagnacova (Lincoln U, '02)

11. O. Ahmadi (Yale, '01)
12. L. Klapp, (Cornell, '00)
13. T. Goeppinger, (U of Illinois, '99)
14. Jairaj Patel (RPI, '03)
15. Chitra Baid (RPI, '00-'02)
16. Erin McLellan (RPI, '01)
17. Ji-Hun Kim (RPI, '01)
18. John Marzano (RPI, '01)
19. Ray Pang (RPI, '00)
20. Mike Ziegerhofer (RPI, '00)
21. Dirk Scholvin (RPI, '99, '00)
22. Rory Leahy (Trinity college, Ireland, '99)
23. Mark Wilkinson (RPI, '99)
24. Matt Stowe (RPI, '99)
25. Greg Verni (RPI, '99)
26. Jon Belfort (U. Roch, '98)

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Main Page | Curriculum Vita | Facilities

Journal Publications | Book Chapter | Conference Articles | Patents | Invited Talks | Contributed Presentations

Journal Publications

2004

1. Template-less assembly of gold nanowire networks from nanoparticles, G. Ramanath, J. D'Arcy Gall, T. Maddanimath, A.V. Ellis, R. Goswami, P. G. Ganesan, A. Kumar, K. Vijayamohanan, Langmuir (2004) *in press*.
2. Nanomachining carbon nanotubes with ion beams, M.S. Raghuveer, P. G. Ganesan, J. Mabon, J D'Arcy-Gall, and G. Ramanath Appl. Phys. Lett. (2004) *in press*.
3. Interfacial phase formation in Cu-Mg alloy films on SiO_2, M.J. Frederick and G. Ramanath J. Appl. Phys. **95** (6) 3202-3205 (2004).
4. Building and testing organized architectures of carbon nanotubes, R. Vajtai, B. Wei, Y. J. Jung, Cao, S. K. Biswas, G. Ramanath and P. M. Ajayan IEEE Trans. Nanotech. **2**(2), 355 (200
5. Silicon oxide thickness-dependent growth of aligned carbon nanotubes by chemical vapor deposition, A. Cao, R. Baskaran and K. Turner, P. M. Ajayan, G. Ramanath, Appl. Phys. Lett. **84** (1), 109 (2004).

2003

6. Tailoring structure and electrical properties of carbon nanotubes using kilo-electron-volt ions, E Q. Wei, J. D'Arcy-Gall, P. M. Ajayan, G. Ramanath Appl. Phys. Lett. **83**(17), 3581 (2003
7. Kinetics of interfacial phase formation and diffusion in Cu-Mg alloy films on SiO_2, M. Frederic and G. Ramanath J. Appl. Phys. **95**, 363 (2003).
8. Polyelectrolyte nanolayers as diffusion barriers for Cu metallization, P.G. Ganesan, J. Gamba, A Ellis, R.S. Kane, and G. Ramanath, Appl. Phys. Lett. **83**(16), 383 (2003).
9. Self assembled nanolayers as adhesion enhancers and diffusion barriers, G. Ramanath, G. Cui, I Stukowski, X. Guo, P. G. Ganesan, A.V. Ellis, K. Vijayamohanan, P. Doppelt, M. Lane, Appl. Phys. Lett. **83**(2), 383 (2003).
10. Exclusive horizontal growth of aligned carbon nanotubes with controlled site-selectivity and length, A. Cao, R. Baskaran, M.J. Frederick, P. M. Ajayan, K. Turner, G. Ramanath, Adv. Mater., **15**(13), 1105 (2003).
11. Near-zero-thickness self-assembled molecular layers for future device structures: Interfacial adhesion and diffusion barrier properties, P. G. Ganesan, G. Cui, A. Ellis, R.S. Kane, and Ramanath, Mater. Sci. Forum **426-432**, 3487-3492 (2003).
12. Assembly of mm-scale macro-bridges with carbon nanotube bundles, A. Cao, P. M. Ajayan, an

Ramanath, Appl. Phys. Lett., **83**(2), 356 (2003).
13. Sequence of Mg segregation and interfacial MgO formation in Cu-Mg alloy films on SiO_2 duri vacuum annealing, M. Frederick, R. Goswami, and G. Ramanath, J. Appl. Phys. **93**, 5966 (2003).
14. Assembly of highly organized carbon nanotube architectures by chemical vapor deposition, B. (Wei, R. Vajtai, Y. Jung, J. Ward, R. Zhang, G. Ramanath and P. M. Ajayan, Chem. Mater **15**, 1598 (2003).
15. Hydrophobic attachment of gold nanoclusters to carbon nanotubes, A. Ellis, K. Vijayamohanan Goswami, N. Chakrapani, L.S. Ramanathan, P.M. Ajayan, and G. Ramanath, Nano. Lett. 279-282 (2003).

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16. Organized assemblies of carbon nanotubes, B.Q. Wei, R. Vajtai, Y. Jung, J. Ward, Y. Zhang, G Ramanath, and P.M. Ajayan, Nature **416**, 495 (2002).
17. Igniting Nanotubes with a flash, P. Ajayan, G. Ramanath, M. Terrones, T.W. Ebbesen, Science **297**, 192-193 (2002) in response to B. Bockrath, J.K. Johnson, D.S. Sholl, B. Howard, C. Matranga, W. Shi, D. Sorescu.
18. Nanotubes in a flash: ignition and reconstruction, P.M. Ajayan, M. Terrones, A. de la Guardia, Huc, N. Grobert, B.Q. Wei, H. Lezec, G. Ramanath, and T. Ebbesen, Science **296**, 705 (2002).
19. Growth of aligned carbon nanotubes on self-similar macroscopic templates, A. Cao, B. Wei, Y. Jung, R. Vajtai, P.M. Ajayan, and G. Ramanath, Appl. Phys. Lett. **81**(7), 1297 (2002).
20. Massive Icosahedral Boron Carbide Crystals, B.Q. Wei, R. Vajtai, Y. Jung, F.R. Banhart, G. Ramanath, and P.M. Ajayan, J. Phys. Chem. **106**(23), 5807 (2002).
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22. Simultaneous growth of SiC nanorods and carbon nanotubes by chemical vapor deposition, B.Q Wei, J. W. Ward, R. Vajtai, R. Ma, P.M. Ajayan, and G. Ramanath, Chem. Phys. Lett. **35** 264-268 (2002).
23. Growth pillars of densely-packed carbon nanotubes on Ni-coated silica, B. Wei, Z.J. Zhang, P.M Ajayan, and G. Ramanath, Carbon **40**, 47-51 (2002).
24. Building carbon nanotubes and their smart architectures R.Vajtai, B.Q. Wei, Z.J. Zhang, Y. Jun G. Ramanath, P. Ajayan, Smart Materials and Structures **11**(5), 691-698 (2002).

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25. Self assembled near-zero thickness molecular layers as diffusion barriers for Cu metallization, A Krishnamoorthy, K. Chanda, S. P. Murarka, J. G. Ryan and G. Ramanath, Appl. Phys. Let **78** (17) 2467 (2001).
26. Carbon nanotube-MgO cube networks, B. Wei, R. Vajtai, Z. J. Zhang, G. Ramanath and P. M. Ajayan, J. Nanosci. Nanotech. **1**, 35-38 (2001).
27. Growth, structure and optical properties of carbon-reinforced silica fibers, Z. Zhang, P. Ajayan, Ramanath, J. Vacik and Y. Xu, Appl. Phys. Lett., **78**(24), 3794 (2001).
28. Reflection high energy diffraction from carbon nanotubes, J. T. Drotar, B.-Q. Wei, Y.-P. Zhao, Ramanath, P. M. Ajayan, T.-M. Lu, and G.-C. Wang, , Phys. Rev. B **64**, 125417 (2001).

29. Select pathways to carbon nanotube film growth, Z. J. Zhang, B. Wei, R. Vajtai, J. Ward. G. Ramanath and P. M. Ajayan, Adv. Mater. **13** (23), 1767 (2001).
30. Frequency dependent electrical transport in carbon nanotubes, Y.-P. Zhao, B. Q. Wei, P. M. Ajayan, G. Ramanath, T.-M. Lu, and G.-C. Wang, A. Rubio and S. Roche, Phys. Rev. B 6 201402 (R) (2001).
31. Thickness dependent electrical resistivity of ultrathin (< 40 nm) Cu films, H.-D. Liu, Y.-P. Zha G. Ramanath, S. P. Murarka, and G.-C. Wang, Thin Solid Films **384**, 151-156 (2001).
32. Creation of Radial Patterns of Carbonated Silica Fibers on Planar Silica Substrates, Z. J. Zhang, Ramanath, P. M. Ajayan, D. Goldberg, Y. Bando, Adv. Mater. **13**(3), 197-200, (2001).

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33. Lift-up growth of aligned carbon nanotube patterns, B.Q. Wei, Z.J. Zhang, G. Ramanath, and P. Ajayan, Appl. Phys. Lett. **77**(19), 2985 (2000).
34. Substrate-site selective growth of aligned carbon nanotubes, Z.J. Zhang, B. Q. Wei, G. Ramana and P.M. Ajayan, Appl. Phys. Lett. **77**(23), 3764 (2000).
35. Channeling-induced profile distortion during SIMS depth profiling of TiN/Ti/TiN(001) thin fil G. Ramanath, J. E. Greene, I. Petrov, J. E. Baker, L. H. Allen and G. Gillen, J. Vac. Sci. Technol. B **18**(3) 1369-1374 (2000).
36. Kinetic rate expression for tungsten chemical vapor deposition in different WF_6 flow regimes fi step coverage measurements, E. J. McInerney, E. Srinivasan, D. C. Smith, and G. Ramana Zeitschrift Für Metallkunde, **91**(7), 573 (2000).
37. W deposition and titanium fluoride formation: reaction path and mechanisms, G. Ramanath, J. I Greene, J. R. A. Carlsson, V. C. Hornback, D. J. Allman and L. H. Allen, J. Appl. Phys., 8 1961 (1999).
38. Kinetics of thin film reactions of Cu/a-Ge bilayers, Z. Wang, G. Ramanath, J. Doyle, L. H. Alle B. B. Svensson and A. Rockett, Appl. Phys. Lett. **82**, 3281(1997).
39. Heat capacity measurements of nanoscale Sn particles using a thin-film differential scanning calorimeter with 0.2 nJ sensitivity, S. L. Lai, G. Ramanath, P. Infante and L. H. Allen, Ap Phys. Lett., **70**, 43 (1997).
40. Gas-phase transport of WF_6 through annular TiN nanopipes during W chemical vapor depositio on $TiN/Ti/SiO_2$ structures for integrated circuit fabrication, G. Ramanath, J. Carlsson, J. E Greene, V. C. Hornback, D. J. Allman and L. H. Allen, Appl. Phys. Lett. **61**, 3179 (1996).
41. Au-mediated low-temperature solid phase epitaxial growth of a SiGe alloy on Si(001), G. Ramanath, H. Z. Xiao, S. L. Lai, L. H. Allen and T. L. Alford, J. Appl. Phys. **79**, 3094 (1996).
42. Size-dependent melting properties of small Sn particles: nanocalorimetric measurements, S. L. J. Y. Guo, V. Petrova, G. Ramanath and L. H. Allen, Phys. Rev. Lett. **77**, 99 (1996).
43. Evolution of microstructure of nanocrystalline Mo-Cu thin films during thermal annealing, G. Ramanath, H. Z. Xiao, L. C. Yang, A. Rockett and L. H. Allen J. Appl. Phys. **78**, 2435 (1995).
44. High-speed (10^4 °C/s) scanning microcalorimetry with monolayer sensitivity (1 J/m^2), S. L. Lai Ramanath, L. H. Allen, Z. Ma and P. Infante, Appl. Phys. Lett. **67**, 1229 (1995).
45. 10^6 °C/s thin film electrical heater: In situ resistivity measurements of Ti/Si films during electri thermal annealing, L. H. Allen, G. Ramanath, S. L. Lai, and D. J. Allman, Appl. Phys. Let **64**, 417 (1994).

Book chapter

46. Thin Film Deposition and Treatment, G. Ramanath, H.S. Goindi, D.B. Bergstrom, in Intermeta Compounds, Principles and Practice **3**, edited by J.H. Westbrook, and R. L. Fleischer (Wi 2002) pp. 663-680.

Conference Articles

Invited

47. Self-assembled molecular nanolayers for device structures, P.G. Ganesan, and G. Ramanath, Proceedings of the International Workshop on Processing of Semiconductor Devices, Chennai, India (2003).
48. Near-zero-thickness self-assembled molecular layers for future device structures: Interfacial adhesion and diffusion barrier properties, P. G. Ganesan, G. Cui, A. Ellis, R.S. Kane, and Ramanath, THERMEC international conference on processing and manufacturing of advanced materials, (July 7-11, 2003), Leganes, Spain.
49. Directed assembly of highly organized nanotube architectures, B. Q. Wei, Y. Jung, A. Cao, P. M Ajayan, and G. Ramanath, Proceedings of the international Symposium on Advanced Applications for Carbon Materials, (Sept 12-13, 2002), Organized by NSF-USA, Carbon Societies of Korea and Japan; Jeju Island, Korea.
50. Electromigration in Epitaxial Cu(001) lines, G. Ramanath, H. Kim, H. S. Goindi, M. J. Frederic C.-S. Shin, R. Goswami, I. Petrov, and J. E. Greene, AIP Proceedings of the 6th Internatio Workshop on Stress-Induced Phenomena in Metallization, edited by S.P. Baker, M. Korhonen, E. Arzt and P. Ho (2001), p. 10.
51. Critical challenges and newly emerging strategies in diffusion barrier technology, G. Ramanath Stukowski, H. Kim, and M. J. Frederick, X. Guo, VLSI Mult. Intercon. Conf. Proc. **18** (Library of Congress No. 89-644090), 153 (2001).
52. Interfacial barriers for the 100-nm node and beyond: key challenges and emerging strategies, G. Ramanath, M. Stukowski, H. Kim, and M. J. Frederick, Inter. Conf. Solid State and Integr Circ. Technol., published by IEEE (Shanghai, China, October 2001) pp 391-96.
53. Building carbon nanotube architectures, R. Vajtai, B. Q. Wei, G. Ramanath, and P.M. Ajayan, SPIE's International SPIE Proceedings on BioMEMS and Smart Nanostructures, edited by L.B. Kish, E.C. Harvey, W.B. Spillman Jr, (Adelaide, Australia, Dec. 17-19 2001) p. 121.

Contributed

54. *Field emission from aligned carbon nanotubes grown on patterned oxide layers*, B.S. Satyanarayana, B.Q. Wei, Y. Jung, G. Ramanath, and P. M. Ajayan, Tech. Digest of IVM 213 (2003).
55. *Phase transitions in octanethiol-capped Ag, Au and CdS nanocluster assemblies A.V. Ellis, K. Vijayamohanan*, C. Ryu, and G. Ramanath, MRS Symp. Proc. Fall Meeting (Dec 2002) in press.
56. *Interfacial adhesion of Cu to self-assembled monolayers on SiO_2*, G. Cui, M. Lane, K. Vijayamohanan, and G. Ramanath, MRS Symp. Proc. **695**, Thin Films: Stresses and Mechanical Properties IX, 329-334 (Dec 2001).
57. *Controlling the aligned growth of carbon nanotubes by substrate selection and patterning*, Y. Jung, B. Q. Wei, R. Vajtai, J. Ward, R. Zhang, G. Ramanath and P. M. Ajayan, MRS Sym

Proc. **706**, Z3.11 (Dec 2001).

58. *Electromigration in epitaxial Cu lines*, H. S. Goindi, C.-S. Shin, M. J. Frederick, Y. Shustermar H. Kim, I. Petrov, and G. Ramanath, in Growth, Evolution, and Properties of Surfaces, Th Films, and Self-Organized Structures MRS Symp. Proc. **648**, 11.37 (2001).
59. *Understanding microchemical changes leading to delamination of TiN/Ti barriers during W CV* G. Ramanath, J. Greene, J. Carlsson, V. Hornback, D. Allman, and L. Allen, VLSI Mult. Intercon. Conf. Proc. **14**, 246 (1997).
60. *F accumulation in Ti: the cause of adhesion failure of TiN/Ti liner on SiO_2 during W CVD?* G. Ramanath, V. C. Hornback, D. J. Allman, J. R. A. Carlsson and L. H. Allen, VLSI Mult. Intercon. Conf. Proc. **13**, 333 (1996).
61. *An ultrafast thin film microcalorimeter with monolayer sensitivity*, S. L. Lai, G. Ramanath, P. Infante, and L. H. Allen, MRS Symp. Proc. **398**, 469 (1996).
62. Evolution of microstructure during low-temperature solid phase epitaxial growth of Si_xGe_{1-x} or (001), G. Ramanath, H. Z. Xiao, S. L. Lai, and L. H. Allen, MRS Symp. Proc. **355**, 365 (1994).
63. *The transformation from $\alpha \rightarrow \gamma$ during continuous cooling in Ti-(47-48) at% Al alloys*, D. Veeraraghavan, G. Ramanath, P. Wang and Vijay K. Vasudevan, in Solid State Phase Transformations, W. C. Johnson, J. M. Howe, D. E. Laughlin, W. A. Soffa (eds.), pp. 273 278 (1994).
64. Formation of $TiSi_2$ during rapid thermal annealing: in situ resistance measurements at heating r from 1 to 25000 °C/s, G. Ramanath, S. Koh, Z. Ma, L. H. Allen and S.Lee, MRS Symp. P **303** , 63 (1993).
65. *Mechanism of C49 to C54 transformation in $TiSi_2$ during thermal annealing*, Z. Ma, G. Raman and L. H. Allen, MRS Symp. Proc. **320**, 361 (1993).
66. *The $\alpha \rightarrow \gamma$ transformation during continuous cooling in Ti-48 at% alloys*, G. Ramanath and Vij K. Vasudevan, MRS Symp. Proc. **288**, 223 (1992).

Patents

67. Template-less room-temperature assembly of nanowires and their networks from nanoparticles, Ramanath, A V. Ellis, R. Goswami, and K. Vijayamohanan, disclosure (April 2004).
68. Polyelectrolyte layers as diffusion barriers for Cu metallization, G. Ramanath, P.G. Ganesan, ar R.S. Kane, disclosure (2003).
69. Nanotube based non-linear optics and methods of making same, S. Curran, P.M. Ajayan, A. Ell G. Ramanath, disclosure (Dec 11, 2003).
70. Directed assembly of highly-organized carbon nanotubes, P.M. Ajayan, G. Ramanath, Y.J. Jung B.Q. Wei, and Z. Zhang, Docket # 60-356,069 (Filed Feb 11, 2002) (RPI 702).
71. Directed assembly of highly organized carbon nanotube architectures by P.M. Ajayan, G. Ramanath, and Bingqing Wei, (filed June 3, 2002) Application # 60/385,393 (RPI 702A).
72. Nanotubes in a flash: ignition and reconstruction, P.M. Ajayan, G. Ramanath, and A. de la Guardia, (Filed February 19, 2002) Docket#60/358,082 (RPI 619).
73. Diffusion barriers comprising a self-assembled monolayer, G. Ramanath, A. Krishnamoorthy, K Chanda, S.P. Murarka, Application#20020079487 (October 11, 2001).
74. Self assembled near-zero thickness layers as diffusion barriers for copper metallization, A. Krishnamoorthy, K. Chanda, S. P. Murarka, G. Ramanath, US Patent Disclosure Docket # 20020105081 (October 11, 2001).
75. A new method for promoting tungsten nucleation during W chemical vapor deposition, G.

Ramanath, V. C. Hornback, D. J. Allman, and L. H. Allen, US Patent 5,963,828 (1999). Issued

Invited Seminars & Talks

1. Cornell University, Electrical Engineering Department Colloquium (March 2004): Mesoarchitectures from nanoscale building blocks: directed assembly and applications
2. TMS Annual meeting—Metals for the future symposium, Charlotte, NC (March 2004): Self-assembled near-zero-thickness nanolayers for nanodevice metallization: Interfacial adhesi and chemical isolation
3. TMS Annual meeting—Surfaces and interfaces in nanostructured materials symposium, Charlo NC (March 2004): Directed assembly of mesoarchitectures and networks from 0-D and 1-nanounits
4. International Conference on Materials for Advanced Technologies—organized by IUMRS at Singapore (Dec, 2003): Directed assembly and properties of highly-organized architecture comprised of 1D nanostructures
5. Twelfth International Workshop on Physics of Semiconductor Devices, Chennai, India (Dec 20 *Use of self-assembled molecular layers for future devices*
6. Cabot corporation, MA (Dec 2, 2003): Synthesis and directed assembly of hybrid heterostructu and mesoscale architectures from 0-D and 1-D nanoscale building blocks
7. Workshop at the Nanoparticles 2003 Conference, Boston, MA (October 26, 2003): Synthesis ar Properties of 1-D Nanostructures.
8. US-Japan Exchange of young scientists at MIT, organized by National Science Foundation, (September 26, 2003): Assembly of mesoarchitectures from nanoscale units
9. THERMEC '2003—organized by TMS at Madrid, Spain (July 7-11, 2003): Near-zero-thicknes self-assembled molecular layers for future device structures: Interfacial adhesion and diffusion barrier properties
10. Indian Institute of Technology, Guwahati, Chemistry Department (June 24 2003): Cool Nanostructures:Directed assembly and new applications
11. Indian Institute of Technology, Delhi, Physics Department (June 19 2003): Cool Nanostructures:Directed assembly and new applications
12. University of Paris, Chemistry Department (Dr. Pileni) Jussieu, Paris, France, (June 11, 2003): Directed assembly of one-dimensional nanostructures: strategies and applications
13. ENEA, Centro Ricerche Casaccia, UTS Materiali e Nuove Tecnologie, Brindisi, Italy, (June 13, 2003): Directed assembly of one-dimensional nanostructures: strategies and applications
14. ENEA, Centro Ricerche Casaccia, UTS Materiali e Nuove Tecnologie, Rome, Italy, (June 12, 2003): Directed assembly of one-dimensional nanostructures: strategies and applications
15. Indian Institute of Technology, Madras, Joint seminar organized by Department of Metallurgica Engineering and Materials Science Research Center (May 7, 2003): Cool Nanostructures: Directed assembly and new applications
16. International Conference on Metallurgical Coatings and Thin Films (ICMCTF), Symposium B, Diego (April 24-28, 2003): Directed assembly of organized nanotube architectures
17. North-East New York chapter of the American Nuclear society, keynote talk, Troy, NY (March 2003): Carbon Nanotubes: Architecture and Applications
18. IBM weekly seminar, T.J. Watson Center, Yorktown Heights, NY (March 21, 2003): Fabricatic and assembly of nanostructures into complex architectures and devices
19. Florida International University, Electrical Engineering and Mechanical Engineering Departmei joint seminar (March 10, 2003): *Highly-organized architectures from 1D nanostructures: directed assembly and future devices*
20. US-Japan Symposium on Tools and Metrology for Nanofabrication at Cornell Nanofabrication Facility, Ithaca, NY (Jan 23, 2003): A perspective on critical challenges and emerging

strategies in fabrication and characterization of mesoscale architectures built with nanoscale uni

21. Pennsylvania State University, State College, PA, Department of Engineering Sciences (Novem 4, 2002): Highly-organized one-dimensional nanostructures: Strategies for directed assem and new applications
22. International symposium on Advanced Applications for Carbon Materials Organized by NSF, Carbon Societies of Korea and Japan; Jeju Island, Korea (Sept 12-13, 2002): Directed assembly of highly organized nanotube architectures
23. Philip Morris USA, Richmond, VA (August 19, 2002): Harnessing multiple microanalysis techniques for studies of complex materials systems and phenomena in engineering applications
24. Technion, Haifa, Israel, Department of Materials Engineering (July 29, 2002): *Near-zero-thickn diffusion barriers and adhesion enhancers by self assembly*
25. RWTH, Aachen, Germany, Department of Materials Chemistry (June 24, 2002): Directed assembly of organized networks of high-aspect ratio nanostructures
26. ESPCI-CNRS, Paris, France, Department of Materials Chemistry (June 18, 2002): Directed assembly of organized networks of high-aspect ratio nanostructures
27. University of California, Santa Barbara, CA Departments of Mechanical Engineering and Mate (April 29, 2002): Directed assembly of organized networks of high-aspect ratio nanostructures
28. Sixth International Workshop on Stress-Induced Phenomena in Metallization Cornell Universit Ithaca, NY (July 2001): Electromigration in Epitaxial Cu(001) lines
29. SPIE's International Symposium on Microelectronics & MEMS, Adelaide, Australia (Dec. 17-1 2001): Interfacial isolation in nanostructures.
30. Sixth Inter. Conf. Solid State and Intergr. Circ. Technol. (IEEE, Shanghai, China, October 2001 Interfacial barriers for the 100-nm node and beyond: key challenges and emerging strategi
31. VLSI Multilevel Interconnection Conference (November 2001): Critical challenges and newly emerging strategies in diffusion barrier technology
32. University of Technology, Sydney, Australia (December 13, 2001): A bottom up approach to growing highly oriented carbon nanotubes in multiple orientations
33. University of Melbourne, Chemistry Department, Australia (December 20, 2001): Highly orien carbon nanotubes architectures by chemical vapor deposition and catalyst templating
34. Monash University, Melbourne, School of Physics and Materials Engineering, Australia (December 19, 2001): Controlled growth of highly oriented nanotubes architectures by chemical vapor deposition
35. Indian Institute of Technology, Delhi, Physics Department (August 13, 2001): Interfacial isolati in thin film device structures: reaction pathways, surface.
36. Indian Institute of Technology, Delhi, Physics Department (August 14, 2001): Tailoring the structure, orientation, alignment and site-selectivity of tubular nanostructures on planar substrates.
37. National Chemical Laboratories, Pune, India (August 10, 2001): Tailoring the structure, orientation, alignment and site-selectivity of tubular nanostructures on planar substrates.
38. Pune University, Physics Department, Pune, India (August 11, 2001): Interfacial isolation in thi film device structures: understanding reaction pathways, and atomic-level engineering of surfaces.
39. University at Binghamton (SUNY), Binghamton, NY, a joint colloquium organized by the Phys and Mechanical Engineering Departments (November 14, 2001): Interfacial barriers for future device applications: understanding reaction pathways & surface-molecular engineering.
40. University at Buffalo (SUNY), Buffalo, NY, Electrical Engineering Department Colloquium (A 7, 2001): Thin film diffusion barriers for interconnect applications: from conventional

technologies to atomic-level engineering.

41. Advanced Vision Technologies, Rochester, NY, (April 6, 2001): Placement and multidirectiona growth of carbon nanotube arrays by CVD.
42. Materials Research Center, Indian Institute of Science, Bangalore, India (Jul 28, 2000): Growth and interfacial interactions in, tubular and layered structures.
43. Institute of Materials Research and Engineering, National University of Singapore, Singapore (. 24, 2000): Tailoring the structure, alignment and site-selectivity of tubular nanostructures planar substrates by catalyst templating.
44. Institute of Materials Research and Engineering, National University of Singapore, Singapore (. 25, 2000): Understanding interfacial interactions and phase formation paths in thin film interconnect structures during IC fabrication.
45. Bhaba Atomic Research Center, Materials Colloquium, Mumbai, India (Jul 17, 2000): Synthesi and interactions in layered and tubular nanostructures.
46. Physics Department, Clemson University, Clemson, SC (Jan. 2000): Phase formation at buried interfaces during tungsten chemical vapor deposition from WF_6.
47. Materials Science and Engineering Department, Cornell University, Ithaca, NY (Feb. 1997): Interactions of WF_6 with buried surfaces in sputter-deposited TiN/Ti bilayers during W C
48. Materials Science and Engineering Department, Rensselaer Polytechnic Institute, Troy, NY (Se 1997): Interactions of WF_6 with buried surfaces in TiN/Ti during W CVD.
49. Department of Metallurgical Engineering, Indian Institute of Technology, Madras, (December 1997): Phase formation and Reactions in TiN/Ti barriers during W CVD.
50. Physics Department, Indian Institute of Technology, Guwahati, India, (December 1997): Interfa reactions of WF6 with TiN/Ti films.
51. Advanced Process Development Division, Symbios Logic Inc.(now LSI Logic), Colorado Sprir CO (June 1996), Delamination of TiN/Ti barriers during W CVD.

Contributed Talks & Presentations

51. Site-selective anchoring of nanoparticles heteroassemblies, M.S. Raghuveer, T. Maddanimath, J Ganesan, G. Ramanath, MRS Fall meeting, Boston (2003). Poster N15.29
52. Layered molecular assemblies as interface isolators and adhesion enhancers for devices, P.G. Ganesan, and G. Ramanath, MRS Fall meeting, Boston (2003). Poster
53. Welding, Slicing, and Doping, of Carbon Nanotubes with Ion Beams, M.S. Raghuveer, J. D'Ar Gall, M. Marshal, I. Petrov, G. Ramanath, MRS Fall meeting, Boston (2003). Poster, R 9.
54. Templateless self-assembly of nanowire cages, T. Maddanimath, J. D'Arcy-Gall, A.V. Ellis, R. Goswami, P. G. Ganesan, K. Vijayamohanan, and G. Ramanath, MRS Fall meeting, Bost (2003). Poster, N15.47
55. Silicon Oxide Thickness-dependent Growth of Carbon Nanotubes, A. Cao, R. Baskaran, K. Tur P.M. Ajayan, G. Ramanath, MRS Fall meeting, Boston (2003). Talk, M1.8
56. Templateless self-assembly of nanowire cages, A.V. Ellis, J. D'Arcy-Gall, R. Goswami, and G. Ramanath, ICMCTF, San Diego (2003).
57. Self-assembled molecular nanolayers as interfacial adhesion enhancers, G. Ramanath, G. Cui, S McConaughy, M. Stukowski, P.G. Ganesan, and A. Ellis, MRS Spring meeting (2003).
58. Templateless self-assembly of nanowire cages, A.V. Ellis, J. D'Arcy-Gall, R. Goswami, P. G. Ganesan, and G. Ramanath, MRS Spring meeting (2003).
59. Sequence and mechanisms of Mg segregation and self-organized interfacial MgO formation in Mg alloy films on SiO2, M.J. Frederick and G. Ramanath, MRS Spring meeting (2003).

60. Ultrathin Polymeric Diffusion Barriers for Cu metallization, P. G. Ganesan, S. McConaughy, G Cui, S. Kanagalingam, R. Kane, and G. Ramanath, MRS Spring meeting (2003).
61. Self-assembled nanolayers as adhesion enhancers at Cu/SiO_2 interfaces, G. Cui, M. Stukowski, Guo, A. Ellis, K. Vijayamohanan, P. Doppelt, G. Ramanath MRS Fall meeting (2002).
62. Phase transitions in octanethiol-capped nanocluster assemblies, A.V Ellis, R. Goswami, K. Vijayamohanan, C. Ryu, and G. Ramanath, Symposium H6 MRS Fall meeting (2002).
63. Hydrophobic attachment of gold nanoclusters to carbon nanotubes, K. Vijayamohanan, A.V. El R. Goswami, N. Chakrapani, L.S. Ramanathan, P.M. Ajayan, G. Ramanath H7.14 MRS F meeting (2002).
64. Interfacial phase formation in Cu-Mg thin films grown on oxidized Si, M.J. Frederick, R. Goswami, G. Ramanath, Symposium Z3.39 MRS Fall meeting (2002).
65. Building macro-scale networks and bridges of aligned carbon nanotubes, A. Cao, Bingqing Wei P.M. Ajayan, G. Ramanath, Symposium H7.9 MRS Fall meeting (2002).
66. Near-zero thickness self-assembled layers for interfacial isolation in future device structures, G. Ramanath, M. Stukowski, G. Cui, X. Guo, and S. Nitta, Symposium A9.6, MRS Fall meet (2001).
67. Adhesion of Cu to self-assembled monolayers on SiO_2 G. Cui, M. Lane, K. Vijayamohanan, G. Ramanath, MRS Fall Meeting symposium L7.7 (Dec 2001).
68. Microstructure Evolution and Interfacial Reactions in Cu-Mg Alloy Films on SiO2, M. J. Frederick, R. Goswami, and G. Ramanath, 48th AVS International Symposium, San Francisco, CA (November 2001).
69. Effect of Interfacial Underlayers on Electromigration in Epitaxial Cu(001) Lines, R. Goswami, S. Goindi, H. Kim, M. J. Frederick, G. Ramanath, C.-S. Shin, I. Petrov, and J. E. Greene, AVS International Symposium, San Francisco, CA, November 2001.
70. Near-zero-thickness molecular-layer diffusion-barriers for interconnect applications, G. Raman K. Chanda, X. Guo, and M. Stukowski, 48th AVS International Symposium, San Francisc CA, November 2001
71. Thermal stability of arc-evaporated Ti1-xAlxN thin films, A. Hörling, L. Hultman, M. Oden, G. Ramanath, P.H. Mayrhofer, C. Mitterer, J. Sjolen, L. Karlsson, 48th AVS International Symposium, San Francisco, CA, November 2001.
72. *Towards building three dimensional architectures of carbon nanotubes*, B. Q. Wei, Y. Jung, R. Vajtai, G. Ramanath, P. M. Ajayan, in Symposium Z: Making Functional Materials with Nanotubes, MRS Fall Meeting, Boston, USA (Nov. 2001).
73. Energy-filtered reflection high-energy electron diffraction from carbon nanotubes, J. T. Drotar, B.Q. Wei, Y.P. Zhao, G. Ramanath, and P.M. Ajayan, T.M. Lu, and G.C. Wang, AVS 48t International Symposium, San Francisco, USA, (Oct 29-Nov 2, 2001).
74. Tailoring growth and properties of nanotube networks for applications, B.Q. Wei, Y. P. Zhao, P Ajayan, and G. Ramanath, AVS 48th International Symposium, San Francisco, USA (Oct Nov 2, 2001).
75. *Tailoring growth of carbon nanotubes*, B.Q. Wei, J. Ward, Z.J. Zhang, R. Vajtai, G. Ramanath, and P.M. Ajayan, International Conference on Science and Technology of Nanostructured Materials, Puri, India (Jan. 4-8, 2001).
76. Tailored growth of aligned nanotube arrays of both vertical and horizontal configurations, G. Ramanath, Moletronics meeting (ONR & DARPA), Lake Tahoe, NV (August 2000).
77. Forming aligned nanotube interconnections between thin Ni layers and Si(001), Bingqing Wei, J. Zhang, P.M. Ajayan, and G. Ramanath, Symposium A: Nanotubes and Related Materia MRS Fall Meeting, Boston, MA (2000).
78. Selective growth of aligned nanotubes on SiO2/Si patterns from xylene-metallocene mixtures, Z Zhang, B. Q. Wei, P. M. Ajayan and G. Ramanath, Symposium A: Nanotubes and Relatec

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79. Modifying the structure and properties of carbon nanotubes by Ga+ irradiation, B. Q. Wei, G. Ramanath, and P.M. Ajayan, Symposium O: Ion Beam Synthesis and Processing of Advanced Materials MRS Fall Meeting, Boston, MA (2000).
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81. Determination of kinetic rate expressions using experimental sticking coefficients with applicat to W CVD, E. J. McInerney, G. Ramanath, E. Srinivasan, D. C. Smith, AVS Meeting, Baltimore, MD (1998).
82. Diffusion and phase formation phenomena during WF6 attack of TiN/Ti liners, G. Ramanath, J. Greene, L. H. Allen, V. C. Hornback, D. J. Allman, and H. A. Withers, Adv. Metall. Inter Syst., San Diego, CA (1997).
83. Understanding microchemical changes leading to delamination of TiN/Ti barriers during W CV G. Ramanath, J. Greene, J. Carlsson, V. Hornback, D. Allman, and L. Allen, VLSI Mult. Intercon. Conf. Santa Clara, CA (1997).
84. F accumulation in Ti: the cause of adhesion failure of TiN/Ti liner on SiO_2 during W CVD? G. Ramanath, V. C. Hornback, D. J. Allman, J. R. A. Carlsson and L. H. Allen, VLSI Mult. Intercon. Conf. Santa Clara, CA (1996).
85. Evolution of microstructure during low-temperature solid phase epitaxial growth of Si_xGe_{1-x} on (001), G. Ramanath, H. Z. Xiao, S. L. Lai, and L. H. Allen, MRS Fall Meeting Boston, M (1994).
86. Formation of $TiSi_2$ during rapid thermal annealing: in situ resistance measurements at heating r from 1 to 25000 °C/s, G. Ramanath, S. Koh, Z. Ma, L. H. Allen and S.Lee, MRS Spring Meeting, San Francisco, CA (1993).
87. The αlpha to gamma transformation during continuous cooling in Ti-48 at% alloys, G. Ramana and Vijay K. Vasudevan, MRS Fall Meeting, Boston, MA (1992).

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